# PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

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# PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Rule 71.1)

| Date of mailing *(day/month/year)* | 04.11.2004 |
|---|---|

| Applicant's or agent's file reference | IMPORTANT NOTIFICATION |
|---|---|
| Ambardekar | |

| International application No. | International filing date *(day/month/year)* | Priority date *(day/month/year)* |
|---|---|---|
| PCT/IN 02/00143 | 02.07.2002 | 02.07.2002 |

Applicant
AMBARDEKAR, Vishvas

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.

2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.

3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

4. **REMINDER**

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices) (Article 39(1)) (see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

The applicant's attention is drawn to Article 33(5), which provides that the criteria of novelty, inventive step and industrial applicability described in Article 33(2) to (4) merely serve the purposes of international preliminary examination and that "any Contracting State may apply additional or different criteria for the purposes of deciding whether, in that State, the claimed inventions is patentable or not" (see also Article 27(5)). Such additional criteria may relate, for example, to exemptions from patentability, requirements for enabling disclosure, clarity and support for the claims.

Name and mailing address of the international preliminary examining authority:

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PATENT COOPERATION TREATY

# PCT

## INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

| Applicant's or agent's file reference<br>Ambardekar | **FOR FURTHER ACTION** | See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416) |
|---|---|---|
| International application No.<br>PCT/IN 02/00143 | International filing date *(day/month/year)*<br>02.07.2002 | Priority date *(day/month/year)*<br>02.07.2002 |
| International Patent Classification (IPC) or both national classification and IPC<br>F16H3/70 | | |
| Applicant<br>AMBARDEKAR, Vishvas | | |

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 7 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 13 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the opinion
   - II ☐ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
   - VI ☐ Certain documents cited
   - VII ☐ Certain defects in the international application
   - VIII ☐ Certain observations on the international application

| Date of submission of the demand | Date of completion of this report |
|---|---|
| 01.02.2004 | 04.11.2004 |
| Name and mailing address of the international preliminary examining authority:<br>European Patent Office - P.B. 5818 Patentlaan 2<br>NL-2280 HV Rijswijk - Pays Bas<br>Tel. +31 70 340 - 2040 Tx: 31 651 epo nl<br>Fax: +31 70 340 - 3016 | Authorized Officer<br>Goeman, F<br>Telephone No. +31 70 340-4086 |

# INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/IN 02/00143

## I. Basis of the report

1. With regard to the **elements** of the international application *(Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17))*:

**Description, Pages**

1-8 received on 11.10.2004 with letter of 30.09.2004

**Claims, Numbers**

1-18 received on 11.10.2004 with letter of 30.09.2004

**Drawings, Sheets**

1/3-3/3 as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

   These elements were available or furnished to this Authority in the following language: , which is:

   ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).

   ☐ the language of publication of the international application (under Rule 48.3(b)).

   ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

   ☐ contained in the international application in written form.

   ☐ filed together with the international application in computer readable form.

   ☐ furnished subsequently to this Authority in written form.

   ☐ furnished subsequently to this Authority in computer readable form.

   ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

   ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

   ☐ the description, pages:

   ☐ the claims, Nos.:

   ☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)).

   *(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)*

6. Additional observations, if necessary:

**V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

1. Statement

| | | | |
|---|---|---|---|
| Novelty (N) | Yes: | Claims | 1-18 |
| | No: | Claims | |
| Inventive step (IS) | Yes: | Claims | 1-4,6-12 |
| | No: | Claims | 5,13-18 |
| Industrial applicability (IA) | Yes: | Claims | 1-18 |
| | No: | Claims | |

2. Citations and explanations

   **see separate sheet**

Re Item V

**Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

1. Reference is made to the following documents:
   D1: US-A-3546972
   D2: US-A-5324240
   D3: SU-A-1411537

2. The document D1 is regarded as being the closest prior art to the subject-matter of claim 1 and discloses (the references in parentheses applying to this document): An eccentric gearbox in which each external gear (22) of the eccentric gear pairs, use minimum three first eccentrics (27) to maintain its orientation; the external gears (22) are connected to the input shaft (21) through second eccentrics (21') to guide the point of contact on the external gears (22) and have their axes revolve around the axis of the input shaft (22); a common shaft (27) is used to mount one of first eccentrics (27) for each external gear ( 22) used to maintain the orientation of the external gear (22), minimum three such common shafts (27) are used to maintain the orientation of the external gears (22); internal gear rims (23); the output shaft (23) is free to rotate with respect to the fixed part (26), output (23) and input shaft (21) are coaxial; first eccentrics (27) connected to the same external gear (22) have approximately same eccentricity, first eccentrics connected to different external gears (22) may have different eccentricities; The subject-matter of claim 1 therefore differs from this known D1 in that internal gear rims are connected to the output shaft assembly and are coaxial with the output shaft and by selecting different eccentric gear pairs, different speed ratios are selected between input and the output shaft. The subject-matter of claim 1 is therefore new (Article 33(2) PCT). The problem to be solved by the present invention may be regarded as to make a compact gearbox with multiple speed ratios with large speed ratios. The solution to this problem proposed in claim 1 of the present application is considered as involving an inventive step (Article 33(3) PCT): although internal gear rims connected to the output shaft assembly and coaxial with the output shaft and by selecting different eccentric gear pairs, different speed ratios are selected between input and the output shaft as such are known from D3, the transmission of D3 is too different from the transmission of D1 to make the combination obvious. Thus independent claim 1, dependent claims 2-4, independent 15 when used in combination with claim 1 and dependent claims 13, 14, 16-18 when depending on claim 1 meet the requirements of the PCT with

respect to novelty and inventive step.

3. The document D2 is regarded as being the closest prior art to the subject-matter of claim 5 and discloses (the references in parentheses applying to this document): an eccentric gearbox in which every internal gear (7) uses minimum three eccentrics (4a,4b,4c) to maintain its orientation, axes of internal gear (7) revolve around axis of the output shaft (10); the external gears (9) are coaxially connected to the output shaft (10); internal gear (7) is connected to the input shaft (2a) assembly through eccentrics (4a,4b,4c); eccentrics (4a,4b,4c) connected to the same internal gear (7) have approximately same eccentricity; eccentrics (4a,4b,4c) connected to different internal gears (7) may have different eccentricities. The subject-matter of claim 5 therefore differs from this known D1 in that by selecting different gear pairs, different speed ratios are obtained between the input shaft and the output shaft. It is however generally known to the person skilled in the art that by selecting different gear pairs, different speed ratios are obtained between the input shaft and the output shaft where circumstances make it desirable. Thus, the subject-matter of claim 5 does not involve an inventive step in the sense of Article 33(3) PCT, and therefore the criteria of Article 33(1) PCT are not met. The additional features of claims 13,14 and 16-18 are merely one of several straightforward possibilities from which the skilled person would select, in accordance with circumstances, without the exercise of inventive skill, in order to solve the problem posed. Thus, the subject-matter of claims 13, 14 and 16-18 when they dependent on claims 5 does not involve an inventive step in the sense of Article 33(3) PCT, and therefore the criteria of Article 33(1) PCT are not met.

4. It is believed that similar objections as in paragraph 3 could have been raised for independent claim 15 when based on claim 5.

5. The subject-matter of claim 6 differs from this known D2 in that the eccentrics are free to rotate on individual common shaft and a gear engagement mechanism is used to the input shaft to one of the many eccentrics. The subject-matter of claim 6 is therefore new (Article 33(2) PCT). The problem to be solved by the present invention may be regarded as to make a compact gearbox with multiple speed ratios with large speed ratios. The solution to this problem proposed in claim 6 of the present application is considered as involving an inventive step (Article 33(3) PCT) as the solution is not shown neither rendered obvious by any available prior art. Thus claim 6, independent 15 when used in combination with claim 6 and dependent claims 13, 14, 16-18 when depending on claim 6 meet the

requirements of the PCT with respect to novelty and inventive step.

6. D2 does not disclose the additional features in claim 7. The subject-matter of claim 7 is therefore new (Article 33(2) PCT). The problem to be solved by the present invention may be regarded as to make a compact gearbox with multiple speed ratios with large speed ratios. The solution to this problem proposed in claim 7 of the present application is considered as involving an inventive step (Article 33(3) PCT): although external gears are mounted on the output shaft assembly and coaxial with the output shaft and a gear engagement mechanism is used to engage the output shaft to only one of the external gears as such are known from D3, the transmission of D3 is too different from the transmission of D2 to make the combination obvious. Thus claim 7, independent 15 when used in combination with claim 7 and dependent claims 13, 14, 16-18 when depending on claim 7 meet the requirements of the PCT with respect to novelty and inventive step.

7. The document D2 is regarded as being the closest prior art to the subject-matter of claim 8 and discloses (the references in parentheses applying to this document): An eccentric gearbox in which the internal gears (7) use minimum three eccentrics (4a,4b,4c) to maintain their orientation. All the eccentrics (4a,4b,4c) connected to the same internal gear (7) have approximately same eccentricity. Eccentrics (4a,4b,4c) connected to different internal gears (7) may have different eccentricities. The subject-matter of claim 8 therefore differs from this known D2 in that the external gears are coaxially connected to the output shaft and by selecting different gear pairs, different speed ratios are obtained between the input shaft and the output shaft. Number of suitable spur gears, equal to that of internal gears are mounted on the input shaft. These spur gears drive the driven gears. These driven gears are coaxial to the axis of the output shaft. These driven gears are connected to separate eccentric disc, one for each internal gear, which guides the internal gears and thus the axis of the internal gear is guided to revolve around the axis of the output shaft. The subject-matter of claim 8 is therefore new (Article 33(2) PCT). The problem to be solved by the present invention may be regarded as to make a compact gearbox with multiple speed ratios with large speed ratios. The solution to this problem proposed in claim 8 of the present application is considered as involving an inventive step (Article 33(3) PCT) as the spur gears connected to separate eccentric disc are neither known from, nor rendered obvious by, the available prior art. Thus claim 8, dependent claims 9-12 and independent 15 when used in combination with claim

8 and dependent claims 13, 14, 16-18 when depending on claim 8 meet the requirements of the PCT with respect to novelty and inventive step.

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## TITLE OF INVENTION

Eccentric Gearbox

## TECHNICAL FIELD

This invention deals with large speed ratio eccentric gearbox with selectable speed ratio. In this gearbox many eccentric gear pairs are assembled in parallel, and are connected to a common input shaft and a common output shaft. In every gear pair, one gear called fixed gear keeps its orientation unchanged with respect to a fixed part and another gear that rotates about its own axis is called as moving gear. The point of contact is moved on to the pitch circle of the fixed gear through some mechanism connected and the moving gear is connected to an output shaft. Difference in number of teeth on the two gears of an eccentric gear pair is kept to one tooth or more. Through proper selection of a particular gear pair any speed ratio from available speed ratios can be selected. In this way, it is possible to make a compact gearbox, with multiple (two or more) speed ratios, to have large speed ratios between input and output shafts. These types of gearboxes are useful in automobiles, and in many other applications where turbines are used mainly as prime movers. Such a gear box can be used in automobiles, robot manipulators, earth moving equipments, space applications, toys, hand held tools and in many other applications.

## BACKGROUND ART

Existing patents:

United States Patent No. 3996816, dated Dec. 14, 1976, titled "Harmonic Drive".

United States Patent No. 3546972, dated Dec. 15, 1970, titled "Profile shifted involute internal gearing".

United States Patent No. 5324240, dated Jun. 28, 1994, titled "Eccentric Gear System".

All the above-mentioned inventions deals with single speed ratio gear drives. In all these inventions it is difficult to have multiple speed ratio gearbox, from which a specific gear ratio can be selected. By using existing eccentric gear drives with turbines as a prime mover, it may be necessary to use a conventional gearbox in series with the eccentric drive.

This invention is based on the work done and applied for international patent bearing the international patent application number PCT/IN01/00150 dated Aug. 29, 2001; configuration 2 and configuration 4 are specifically used for present work. Using the configurations 2 and 4 it is possible to make an eccentric gearbox to have multiple (two or more) high speed ratios, any of the available speed ratios can be selected between input and output shaft by employing a suitable gear engagement mechanism. Though eccentric gearbox with any number of speed ratios can be made with following methodology, only three speed ratio gearboxes are explained below.

**Definitions:**

**Internal gear** - A circular gear with internal teeth.

**External gear** - A circular gear with external teeth.

**Fixed gear** – The gear with fixed orientation.

**Moving gear** – The gear that rotates about its own axis.

**Pitch circle** - A reference circle on the plane normal to the rotational axis of the gear, the diameter of the pitch circle is used for calculations.

**Pitch Cylinder** - A cylinder, co-axial to the rotational axis of the gear, that passes through the pitch circle of the gear. As most of the time the gear cross section is referred, only pitch circle is referred in the explanation that follows.

**Point of contact** - Theoretical common point on the pitch circles of the two meshing gears. The two pitch circles are tangential to each other on this point.

**Line of contact** - Theoretical common line on the pitch cylinders of the two meshing gears. The two pitch cylinders are tangential to each other on this line. This line is always parallel to the axes of the two gears and passes through the point of contact. As most of the time the gear cross section is referred, only point of contact is referred in the explanation that follows.

**Eccentricity** - Half the difference between the pitch circle diameters of the two meshing gears forming eccentric gear pair as in FIG. 1, FIG. 2 and FIG. 3. The eccentricity should preferably be same for all eccentric parts related to a particular gear pair.

**Introduction:**

A gearbox with large speed ratio is very useful. This type of gearbox uses eccentric gear pair for obtaining large speed ratio; this makes it very compact in size for large speed ratio. With an eccentric gearbox, it may be possible to use a turbine as a prime mover for automobiles and for many other applications, without use of conventional gearbox. Use of such a gearbox can make very compact turbine-gearbox unit and can replace the conventional reciprocating engine-gearbox unit in future. An eccentric gearbox can allow utilizing the benefits of using turbine over the use of reciprocating internal combustion engine.

The working of such an eccentric gearbox is explained with the help of three drawings. These three drawings as listed below, give details of three different possible configurations of such a gearbox.

**FIG. 1-** Schematic sectional view of a three speed eccentric gearbox, with external gears as fixed gears and internal gears as moving gears. Input shaft is connected to the eccentrics and output shaft is co-axially connected to the internal gears.

**FIG. 2** - Schematic sectional view of a three speed eccentric gearbox, with external gears as moving gears and internal gears as fixed gears. Input shaft is connected to the eccentrics and output shaft is connected to the external gears.

**FIG. 3** - Schematic sectional view of a three speed eccentric gearbox, with external gears as moving gears and internal gears as fixed gears. Input shaft is connected to the additional driving gears and output shaft is connected to the external gears.

**Principle of operation:**

In FIG. 1, 1 is the input shaft, which is supported by the fixed member 4 at one end and output shaft 2 at the other end. Supporting disc 5 gives additional support to the input shaft. Output gear assembly 6 rotates freely in between 4 and 5. The input shaft rotates freely at the support by disc 5. The input shaft rotates freely in 4 and 2. The output shaft 2 and output gear assembly 6 is freely rotating with respect to the fixed part 4. Symbolic gear engagement mechanism 3 is placed to connect one of many ( actual number of eccentrics is equal to that of eccentric gear pairs) eccentrics 10, 14, and 18 to the input shaft. These eccentrics 10, 14, 18 are guiding fixed gears 8, 12, 16 and are freely rotating in the gears 8, 12, 16. The gears 8, 12, 16 are kept in same orientation through the eccentrics 9, 13 and 17 which are either fixed or free to rotate on the shaft 19. There are minimum three similar assemblies of shaft 19 and eccentrics 9, 13 and 17. If the eccentrics 9, 13 and 17 are free to rotate on the shaft 19, then the shaft can be fixed to the supporting disc 5 and to the fixed member 4, otherwise the shaft should be free to rotate in supporting disc 5 and fixed member 4.This shaft 19 and the eccentrics 9, 13, 17 are arranged at minimum three places in such a way that all axes of the shafts 19 are parallel but all are not in the same plane. Shafts 19 are also supported by disc 5. Internal gear rims 7, 11, 15 are mounted on 6 and thus connected to the output shaft 2. Eccentricities of 9, 13 and 17 are

independent of each other. Eccentricity of all 9's and 10 must be approximately same. Similarly eccentricity of all 13's and all 17's should be approximately same as that of 14 and 18 respectively. Eccentrics 10, 14 and 18 are put on shaft 1 in such a way that their axial movement along axis A1 is restricted. Only one of the eccentrics 10, 14, 18 is engaged to shaft 1 at a time through gear engagement mechanism 3 and other two are free to rotate on shaft 1.

When input shaft 1 is rotated the eccentric 14 (FIG. 1) also rotates, this forces axis of gear 12 to revolve around axis A1 and thus the point of contact is forced to move on the pitch circle of the fixed gear 12. Three numbers of eccentric 13 maintain the orientation of the gear 12. The gear rim 11 and thus output shaft 2 rotates about axis A1. If gear 12 has N number of teeth and gear rim 11 has M number of teeth, where M > N, then the speed ratio obtained is M:(M-N).

In FIG. 1, it is also possible to rigidly connect the eccentrics 10, 14 and 18 on to the input shaft 1 and use a gear engagement mechanism to engage one of the gear rims 7, 11 and 15 with the output shaft assembly 6. Other two gear rims, which are not engaged to the output shaft assembly 6, should be free to rotate with respect to the output shaft assembly 6. Gear pair 7, 8, gear pair 11, 12 and gear pair 15, 16 are the eccentric gear pairs in FIG. 1. Theoretical lines of contact for different gear pairs are shown by 20, 21 and 22 in FIG. 1. Joint between gear rims 7, 11, 15 and the output shaft assembly 6 is not shown in the FIG. 1.

In FIG. 2, Input shaft 4, which rotates freely in fixed part 3, is rigidly connected to eccentrics 7, 10 and 13. There are minimum three such similar shaft assemblies comprising of shaft 4 and eccentrics 7, 10 and 13. Axes of all the shafts 4 are parallel but all are not in the same plane. One of the shafts 4 is used as input shaft. Eccentrics 7, 10 and 13 on shaft 4, other than on the

input shaft, are either free to rotate or rigidly connected to the shaft 4. On the shaft 4, which is used as input shaft, all the eccentrics 7, 10 and 13 are rigidly fixed. In the case where the eccentrics 7, 10 and 13 rotate freely on shaft 4, the shaft 4 can be fixed to part 3. Internal gear 5, 8 and 11 are held in unchanged orientation with the help of eccentrics 7, 10 and 13 respectively. Eccentricities of 7, 10 and 13 are independent of each other but all the 7s should have approximately same eccentricity, similarly all 10s and all 13s should also have approximately same eccentricity respectively. External gears 6, 9 and 12 are free to rotate on the output shaft 1. One of the external gears 6, 9 and 12 can be engaged to output shaft 1 at a time by gear engagement mechanism 2. Shaft 4 and shaft 1 are supported in fixed body 3. Shaft 1 rotates free with respect to the fixed body 3. Gear engagement mechanism 2 can select any of the gear pair 5, 6, gear pair 8, 9 and gear pair 11, 12. As shown in the FIG. 2, if internal gear has M number of teeth and external gear has N number of teeth, where M > N, then the speed ratio obtained is N:(M-N).

In a different configuration based on FIG. 2, it is possible to keep the eccentrics 7, 10 and 13 to rotate freely on the input shaft 4 and use suitable engagement mechanism to engage only one of the eccentrics 7, 10 and 13 with the input shaft 4, in such case all other eccentrics 7, 10 and 13 are free to rotate on the respective shaft 4. In this case all the moving gears 6, 9 and 12 are to be fixed with the output shaft 1. Gear pair 5, 6, gear pair 8, 9 and gear pair 11, 12 are the eccentric gear pairs in FIG. 2. Theoretical lines of contact for different gear pairs are shown by 14,15 and 16 in FIG. 2.

In FIG.3, three driving gears 17, 18 and 19 are mounted on input shaft 1 in such a way that at any time only one of the driving gears can be engaged to shaft 1 through symbolic gear engagement mechanism 3, other driving gears rotate freely on the shaft 1. Output shaft 2 is rigidly connected to the three external moving gears 7, 11 and 15. Three eccentrics 5, 9 and 13 are either

fixed or free to rotate on the support shaft 4. Shaft 4 is free to rotate with respect to the fixed support 20, 21, if any of the eccentrics 5, 9 and 13 is fixed on to the shaft 4. If the eccentrics 5, 9 and 13 are freely rotating on the shaft 4, then the shaft 4 can be fixed rigidly to the fixed support 20, 21. Minimum three assemblies of shaft 4 and the eccentrics 5, 9 and 13 maintain the orientation of the internal gear rims i.e. the fixed gears, 6, 10 and 14. The axes of these three similar assemblies of shaft 4 and eccentrics are parallel but not all are in the same plane. The point of contact between the gear pair 6, 7, gear pair 10, 11 and gear pair 14, 15 are moved by eccentric discs 8, 12 and 16 respectively. These eccentric discs 8, 12 and 16 are rigidly connected to gears driven by driving gears 17, 18 and 19. The axes of rotation of these driven gears and the eccentric discs 8, 12 and 16 are coincident with the axis of the output shaft 2. These driven gears and the eccentric discs are free to rotate on the output shaft 2. The eccentric discs 8, 12 and 16 are free to rotate with respect to the internal gear rims 6, 10 and 14 respectively, and thus move the point of contact on the pitch circle diameter of the fixed gears.

In another possibility, in FIG. 3, all the driving gears 17, 18 and 19 can be fixed to the input shaft 1 and the symbolic gear engagement mechanism 3 can be used to engage only one of the moving gears 7, 11 and 15 to output shaft 2, other two moving gears are free to rotate on the output shaft 2. As shown in the FIG. 3, if internal gear has M number of teeth and external gear has N number of teeth, where M > N, then the speed ratio obtained between the eccentric disc assembly and the output shaft is N:(M-N). It is important here that the eccentricities of the eccentric disc and the eccentrics should be approximately same for a particular gear pair; otherwise the eccentricities of the eccentrics are independent of each other. Gear pair 6, 7, gear pair 10, 11 and gear pair 14, 15 are the eccentric gear pairs in FIG. 3. Theoretical lines of contact for different gear pairs are shown by 22, 23 and 24 in FIG. 3.

In all the above-mentioned gearboxes additional eccentrics, eccentric parts and related identical gears, gear rims or eccentric gear pairs can be used simultaneously at appropriate phase difference. This may reduce vibration and increase balancing in the gearbox. For the parts, which are free to rotate, appropriate use of bearings will reduce friction. In above description gear teeth are not shown for simplicity of understanding. It is possible to employ two gear engagement mechanisms instead of one, this will make only one gear pair to get engaged at a time, other gear pair will be totally out of engagement, and thus may increase the life of the gearbox; this may introduce high impact at the time of changing the engaged gear pair. Proper lubrication scheme has to be worked out as per the specific application.

**Advantages of the eccentric gearbox:**

In an automobile if a turbine is to be used then immediately after the turbine output shaft one high ratio gear reduction is necessary. After this high ratio gear reduction conventional gearbox is to be used. This makes the total system unnecessarily bulky, instead, if the eccentric gearbox is used it will eliminate the use of conventional gearbox and will make the system more compact. In this type of eccentric gearbox, it is possible to have more than one speed ratios.

**Disadvantages:**

As many eccentrics are used and high input speed is involved, balancing of the gearbox has to be carried out very carefully.

## CLAIMS

1. An eccentric gearbox in which each external gear of the eccentric gear pairs, use minimum three eccentrics to maintain its orientation; the external gears are connected to the input shaft through eccentrics to guide the point of contact on the external gears and have their axes revolve around the axis of the input shaft; a common shaft is used to mount one of the eccentrics for each external gear used to maintain the orientation of the external gear; minimum three such common shafts are used to maintain the orientation of the external gears; internal gear rims are connected to the output shaft assembly and are coaxial with the output shaft; the output shaft assembly is free to rotate with respect to the fixed part; output shaft and the input shaft are coaxial; eccentrics connected to the same external gear have approximately same eccentricity; eccentrics connected to different external gears may have different eccentricities; by selecting different eccentric gear pairs, different speed ratios are selected between the input shaft and the output shaft.

2. An eccentric gearbox as claimed in claim 1 in which one of the common shafts, on which the eccentrics are mounted to maintain the orientation of the external gears, is used as input shaft; the shaft, which was stated as input shaft in claim 1 and is coaxial to the output shaft, is used to support the eccentrics for guiding the external gear; the eccentrics used for guiding the external gear are free to rotate on the supporting shaft.

3. An eccentric gearbox as claimed in claims 1 and 2 in which a gear engagement mechanism is used to engage at a time only one of the eccentrics, mounted on the input shaft, to the input shaft; other eccentrics on the input shaft are free to rotate with respect to the input shaft; all the internal gear rims are rigidly connected to the output shaft assembly.

4. An eccentric gearbox as claimed in claims 1 and 2 in which a gear engagement mechanism is used to engage at a time only one internal gear rim to the output shaft assembly, other internal gear rims are free to rotate with respect to the output shaft assembly; all the eccentrics mounted on the input shaft, are rigidly connected to the input shaft.

5. An eccentric gearbox in which every internal gear of the eccentric gear pair uses minimum three eccentrics to maintain its orientation; axes of internal gear revolve around axis of the output shaft; the external gears are coaxially connected to the output shaft; internal gears are connected to the input shaft assembly through eccentrics; eccentrics connected to the same internal gear have approximately same eccentricity; eccentrics connected to different internal gears may have different eccentricities; by selecting different gear pairs, different speed ratios are selected between the input shaft and the output shaft.

6. An eccentric gearbox as claimed in claim 5 in which one of the eccentrics used for maintaining orientation of individual internal gears are mounted on a common shaft, and minimum three such common shafts are used; one of these shafts, with appropriate modification, is used as input shaft; these eccentrics are free to rotate on individual common shaft and a gear engagement mechanism is used to engage the input shaft at a time to only one of many eccentrics on the input shaft; external gears are rigidly connected to the output shaft and are coaxial to the output shaft.

7. An eccentric gearbox as claimed in claim 5 in which one of the eccentrics for each internal gear, used to maintain the orientation of the internal gears, are mounted on a common shaft, and minimum three such common shaft assemblies are used; one of these shaft assemblies on which the eccentrics are rigidly mounted is used as input shaft; external gears are mounted on to the output shaft assembly and are coaxial to the

output shaft; these external gears are free to rotate on the output shaft and a gear engagement mechanism is used to engage the output shaft at a time to only one of the external gears on the output shaft.

8. An eccentric gearbox in which the internal gears of the eccentric gear pairs use minimum three eccentrics to maintain their orientation; the external gears are coaxially connected to the output shaft; all the eccentrics connected to the same internal gear have approximately same eccentricity; eccentrics connected to different internal gears may have different eccentricities; by selecting different eccentric gear pairs, different speed ratios are selected between the input shaft and the output shaft; number of, suitable spur gears, equal to that of internal gears are mounted on the input shaft; these spur gears drive the driven gears; these driven gears are coaxial to the axis of the output shaft; these driven gears are connected to separate eccentric disc, one for each internal gear, which guides the internal gears and thus the axis of the internal gear is guided to revolve around the axis of the output shaft.

9. An eccentric gearbox as claimed in claim 8 in which the different eccentrics, used to maintain the orientation of the individual internal gears, are mounted on a common shaft and are either fixed to the shaft or free to rotate on the shaft; minimum number of such common shafts used is three.

10. An eccentric gearbox as claimed in claims 8 and 9 in which the spur gears, that are mounted on the input shaft are free to rotate on the shaft, only one of the gears at a time is engaged to the input shaft by gear engagement mechanism; external gears of the eccentric gear pairs are rigidly connected to the coaxial output shaft.

11. An eccentric gearbox as claimed in claims 8 and 9 in which the spur gears are rigidly mounted on the input shaft; external gears of the eccentric gear

pairs are coaxially connected to the output shaft and are free to rotate on the output shaft; at a time only one of the external gears of the eccentric gear pairs is engaged to the output shaft by gear engagement mechanism.

12. An eccentric gearbox as claimed in claims 8 and 9 in which one of the common shafts having the eccentrics used for maintaining the orientation of the individual internal gear, is used for gear engagement mechanism; all the eccentrics on this shaft, used for maintaining orientation of the internal gear are free to rotate on the shaft; only one of the eccentric is engaged at a time to the shaft by gear engagement mechanism.

13. An eccentric gearbox as claimed in claims 1 to 12 in which two gear engagement mechanisms are used appropriately as to engage only one eccentric gear pair at a time between the input and output shaft; gears of other eccentric gear pairs are not engaged to either input shaft or output shaft.

14. An eccentric gearbox as claimed in claims 1 to 13 in which more than one identical eccentric gear pairs are used; with the help of additional eccentrics or some other mechanism, one or more eccentric gear pairs are engaged simultaneously to input and output shafts.

15. An eccentric gearbox as claimed in claim 1 to 14 in which the input shaft is used as output shaft and the output shaft is used as input shaft.

16. An eccentric gearbox as claimed in the claims 1 to 15 in which one or more eccentric gear pairs are used for getting different speed ratios between input and output shafts.

17. An eccentric gearbox as claimed in the claims 1 to 16 in which suitable lubrication scheme and bearings are used appropriately for reducing friction.

18. An eccentric gearbox as claimed in the claims 1 to 17; which is used for obtaining multiple speed ratios between input and output shaft so that any one of the speed ratios can be selected for use.